Introduction

Epoxy die attach, sometimes referred to as epoxy die bonding, is the most commonly used die attach method. Whether dispensed or daubed via single pin or stamp transfer, it is a more cost-effective solution compared to eutectic bonding; this is due to lower material and process costs. Typical epoxy die attach applications include: Simple transistors, encapsulation of wire bonds, LED attachment, MCMs, and complex hybrids. Hybrid microcircuits, in particular, have seen tremendous growth in popularity due to their built-in flexibility and small package sizes. Aerospace and defense, medical, and optoelectronic device manufacturers have integrated the hybrid package to achieve multiple-need and multi-performance requirements. With rapid time-to-market needs, automating the packaging process has become more critical than ever before. Epoxy die attach is a consistent, reliable, and flexible form of component attach. Automated epoxy dispense systems have kept up with these advances by maintaining a high level of control, handling, and integration through sophisticated process control software.

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High-Precision Component Epoxy Attach:

Market segments demanding high-reliability also require high precision. To achieve both high-reliability and high-precision when using epoxy, the bonding platform must be rigorously consistent and stable, as well as tolerant to fluctuations in temperature and humidity. Also, the epoxy must be carefully controlled to provide suitable substrate, component, and die coverage.

Only a sophisticated die attach machine can achieve such high-precision epoxy attach. One such machine, the Palomar 3880 die bonder, can be retrofitted with a single, dual, or triple dispense bracket for use with time-pressure, auger, or jet dispense options.

In addition, having the ability to do both epoxy dispense and die placement significantly reduces your capital outlay and often valuable production floor space. Further, training costs are lower as you only have a single system to learn.

Epoxy Daubing – Single Pin and Stamp Transfer

One challenge of placing extremely small die is depositing the appropriate epoxy dot size. Making an epoxy dot that is smaller than the die while maintaining precision and reliability is critical for a good bond. This challenge can be overcome with the use of the Palomar adjustable Daub Pot. For applications that use daubing, the automated daub tool is dipped into the daub pot that contains the epoxy, and transferred onto the package or die surface. The transferred dots can be as small as 0.127mm (5mils) and in the form of a single dot or a matrix of dots depending on the geometry and size of the daub tool. The Palomar 3880 Die Bonder can accommodate multiple individually controlled daubing stations and tools.
Epoxy Dispensing – Overview

Typically, for larger devices, a pattern of dispensed lines and dots is needed to achieve full epoxy coverage. Time-pressure, auger, or jet dispensing can be used to for this purpose.

Time Pressure

As the name implies, time-pressure dispense works by applying a pulse of air-pressure to the top of the syringe, forcing the fluid inside to be pushed through the dispensing needle. This method of dispense is fast, easy to use and requires no cleaning; just toss and replace as needed.

The volume of the dispensed fluid depends on the pressure, speed, fluid viscosity, and diameter of the needle. - Typical dispense height of 1-5 Mil

Auger

Auger valve dispensing works by applying constant air pressure to a fluid syringe. As the rotating helical screw blade in the auger valve spins, fluid is forced through the dispensing needle and onto the package or die surface. This method of dispense is highly accurate and volume controlled, resulting in a system that is much less affected by changes in viscosity due to temperature. One drawback of Auger dispensing, however, is that it oftentimes requires more work to setup and clean.

The volume of the dispensed fluid depends on the pressure, RPMs of the screw blade, fluid viscosity, and diameter of the dispensing needle. - Typical dispense height of 1-5 Mil

Jetting

Unlike time-pressure and auger dispense, jetting is a non-contact dispensing method that works by shooting individual dots of epoxy at speeds of up to 333 dots/sec. Lines and dots can be dispensed well above the package surface, without being affected by surface irregularities or roughness. This method of dispense offers incredible throughput and precision but requires a longer time to setup and clean.

The volume of the dispensed fluid depends on the pressure, stroke length, nozzle size, temperature, viscosity, and piston frequency. - Typical dispense height of 1-200+ Mil

Note: Standard dispense needles range in size from 0.15-1.77 mm in diameter.
Epoxy Dispensing – Software Integration

Tightly regulated dispensing allows for the customization of epoxy patterns. Pre-cure and post-cure accuracy is accomplished using symmetric epoxy patterns. The Palomar 3880 offers a range of pre-defined patterns, as well as the option to create patterns entirely from scratch.

In addition, patterns comprised of both lines and dots can be layered to ensure full coverage. All parameters associated with each dispense pattern can be adjusted during production. The display window gives the user an instant graphical representation of the dispense pattern size in comparison to the place site. This means that all the dispense patterns can be optimized with little additional process development time.
Conductive Epoxy Process

A conductive epoxy application calls for the application of dots, lines, or patterns of conductive epoxy to a package, gold stud bump, lid, etc. This, of course, is done to create an electrical, thermal, and structural bond. As a variation of this solution for stud bumps, the epoxy can be placed on the opposing pad in the package.

Conductive epoxy can also be used as an alternative ball bump material in some circumstances.

Non-Conductive Epoxy Process

This die attach method allows an adhesive material to fill the void between the component and the package. Some traditional uses are:

- Isolation – This is not necessarily a process but more of an application. For processes, this lies under staking as it uses UV adhesive for structural attachment only.

- Isolation – Depositing adhesive to prevent electrical connections; such as to prevent bridging from one capacitor end to the other, or to create a dam to separate two components and their conductive adhesive.

- Optical components – i.e., lens, rotator, etc. attach for optoelectronics packages

- Underfills – the space between the chip and the substrate is filled with a non-conductive adhesive (underfill). The underfill material is dispensed around the edge of the die, and capillary action pulls the material under the die.

- Encapsulation – Epoxy is used to fully enclose and surround the assembly for both structural support and protection of the wire bonds and die surfaces.

Figure 10 Auger and Time-Pressure Dispense - Conductive vs. Non-Conductive Epoxy

Figure 11 Encapsulation of a die using the dam and fill method.
Other Adhesive Types

- **UV-curable** – A material that cures with exposure to UV light rather than the conventional heat. For UV curable adhesives, wavelength of light is important, with the most common wavelength being 365nm.

- **Anisotropic conductive adhesives (ACA)** – A material that is comprised of a non-conductive adhesive and conductive particles suspended within. The conductive particles are sparse and far enough apart to not form an electrically conductive path under normal circumstances. A common use for this adhesive is to create small interconnections between flip chip bumps and pads on a substrate. These raised metal contact points trap the small conductive particles and create an electrical connection when compressed. The rest of the adhesive is not compressed enough within the open spaces and does not create an electrically conductive path, thereby preventing shorting. This adhesive then results in multiple conductive paths only where necessary and a strong structural and non conductive filling between component and substrate.

![Anisotropically conductive adhesive](image)

Figure 12  Particles in anisotropic adhesive forming conductive pathways between bond pads.

### Epoxy Application Examples

Palomar Technologies developed a thermoset anisotropic conductive paste attach (ACP) flip-chip process.

Each part requires a bumped 450µm RFID component flip-chip attached to a PCB array and an epoxy underfill. The underfill process is inherent to the ACP process. All parts had to be assembled onto a 200mm x 150mm substrate with 179 sites per PCB.

![Epoxy Application Examples](image)

Figure 12 Palomar 3880 Die Bonder

Figure 13  In a standard-array LED, each LED is wire bonded to a substrate pad. LEDs can be addressed individually or tied together. Many of these types of assemblies are die-attached with epoxy.

Figure 14  In this example, a completed substrate containing both eutectic and adhesive attachments using mixed attachment technology is shown; component spacing and material outflow can easily be compared.
Using Dam and Fill Method as a Protective Barrier

This method of chip encapsulation is used for added protection of electronic components on a circuit board. First, a damming compound is applied to create a structurally sound barrier around the component. The advantage of this is that it cures in place and does not run.

Once the damming compound is cured, a low viscosity, low shrinkage filler is then applied to cover the component, including both wire and die bonds for protection.

The advantages of the dam and fill method are that the flow is controlled and restricted; it can be applied to a more extensive section of the board. Because the filling compound flows better than globbing, there is better protection around the component.

Figure 15  Epoxy is used to fully enclose and surround the assembly for both structural support and protection of the wire bonds and die surfaces.

Summary

Epoxy die attach is a low cost attachment method that is often faster, and more flexible than conventional eutectic die attach. Although it does not boast the same thermally conductive bonds that eutectic die attach does, it offers the ability to create precise electrically conductive paths without the risk of shorting through the use of various adhesive types. Both the conductive and non-conductive solutions can be applied via dispense, jetting, or pin transfer for both extremely small and large components, while maintaining controlled, repeatable bonds. Applying these adhesives with extreme precision is necessary to make the most of the control that epoxy has to offer. Automated die bonding systems such as the Palomar 3880 and 6500 are prime examples of platforms that can make the most of epoxy die attach, by offering access to all epoxy die attach process methods while being highly stable, precise, and customizable.
**PALOMAR 3880**

**DIE BONDER**

The Palomar 3880 Die Bonder component placement die attach system features a state of the art, integrated 2-Theta bidirectional 8-tool bond head, making it the fastest, most reliable, and flexible multiple die bonder on the market. Designed based on industry-proven capabilities, the Palomar 3880’s versatility includes both eutectic and epoxy die attach, flip chip, as well as a range of options in a single machine.

- **VisionPilot®**
  VisionPilot with Radar Referencing pattern recognition software to maximize throughput.

- **Bond Data Miner**
  An all-inclusive and centralized data management and analysis system that is a powerful tool to improve yield and utilization.

- **Industry 4.0**
  Engineered for Industry 4.0 communications.

- **Service Contract**
  Achieve maximum ROI by adding a service contract complete with preventative maintenance visits.

- **Dynamic Axis Correction**
  Maintains positional accuracy through active thermal compensation.

- **Offline Programming**
  Maximize machine utilization.

- **Speed**
  Cycle Time: to 1200 UPH, axis speeds near 40 ips with resolution of 0.1µm over work area. Tool Change Speed: 0.25 seconds

- **Placement Accuracy**
  <5µm (0.000196 inch), 3σ

- **Repeatability**
  Placement: 3.5µm, 3σ Planar: 0.00361 degree, 3σ

- **Large Work Area**
  914.4 x 508.0 mm (36 x 20 inch) work envelope for a versatile automated die bonder capable of handling many different part types, presentation options, and application processes.

- **Look-Up Camera**
  Integrated with PR system:
  - Calibration of tool positions
  - Flip chip vision processing
  - Programmable on/off axis lighting

**NEW PALOMAR VISION STANDARDIZATION™**
Standardizes the vision system across bonding platforms, allowing for seamless transfer of programs between systems.

**VISIONPILOT® WITH RADAR REFERENCING®**
Utilizes advanced geometric pattern matching technology to reliably and accurately locate parts that are randomly oriented or have greyscale variations by using a set of boundary curves that are not tied to a traditional pixel-grid.

**BOND DATA MINER™**
A comprehensive and centralized data management and analysis system that provides machine and process trend monitoring for increased yields and predictive maintenance.

**TYPICAL APPLICATIONS**

- AOC - Active optical cable
- HB/HP LED assembly
- RF packages
- MEMS / MOEMS
- Solid state lasers
- LED printhead attachment
- Chip-on-board
- Microwave modules
- Hybrid microcircuits
- VCSEL, PD, DFB Laser, Lens Attach
- RF GaN 5G power amplifiers
- RF power amplifier
Making the connected world possible™

Making the connected world possible by delivering a Total Process Solution™ for advanced photonic and microelectronic device assembly processes utilized in today’s smart, connected devices. With a focus on flexibility, speed, and accuracy, Palomar’s Total Process Solution includes die bonders, wire and wedge bonders, vacuum reflow systems, along with Innovation Centers for outsourced manufacturing and assembly, and Customer Support services, that together deliver improved production quality and yield, reduced assembly times, and rapid ROI.

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